

is perhaps more astonishing still, there is no description or statement of any kind about the septibranch Pelecypoda. The statement that there are nephrostomes in *Amphioxus* needs correction, and the retention of the *Ctenophora* as a class of *Cœlenterata* justification.

Several new figures have been introduced into the ninth edition, and these are all of considerable value, but it is a pity that the only illustrations of the large and important order of the *Alcyonaria* are copied from the old, and in some respects incorrect, figures by de Lacaze Duthiers of *Corallium rubrum*. It is very desirable that a figure of a *Pennatulid* and some drawings of *Alcyonarian* spicules should be added. A better figure of *Millepora* should be found than that which appears on p. 217. But with all these faults, which are many when the book is critically examined, there can be no question that in general scope and breadth of treatment Hertwig's "*Lehrbuch der Zoologie*" is one of the most notable of the textbooks of our times.

COSMOGONY AND GEOPHYSICS.

Scientific Papers. By Sir George Howard Darwin, K.C.B., F.R.S. Vol. iii., *Figures of Equilibrium of Rotating Liquid and Geophysical Investigations*. Pp. xvi+527. (Cambridge: University Press, 1910.) Price 15s. net.

THIS volume opens with the well-known paper, "On the Influence of Geological Changes on the Earth's Axis of Rotation" (1877), in which Sir George Darwin investigated whether it was possible for known causes to produce a motion of the earth's axis comparable with that required by geologists to account for the supposed "Glacial period" in the earth's history. The result is definitely established that any change in the obliquity of the ecliptic which can have been produced by gradual deformation of the earth's shape is necessarily very small, about $1/2200$ of a second of arc at most. The possibilities of wanderings of the pole are shown to be greater—from 1° to 3° in each geological period is possible. Cumulative motions of this type might account for the change since the supposed Glacial period, but any such explanation would be incompatible with the belief of geologists that where the continents now stand they have always stood.

This important paper is followed by six shorter ones, and the remaining eight papers, all of them of extreme complexity, deal with figures of equilibrium of rotating liquid.

A mass of fluid left to itself will, of course, form into a sphere under the gravitational action of its parts. If set into rotation this sphere will flatten at the poles, and Maclaurin showed that the flattened bodies corresponding to all degrees of rotation may be a series of spheroids so far as conditions of equilibrium are concerned, although obviously the very flat figures would be unstable. It has been known for some time that these spheroids are not the only figures of equilibrium. Jacobi found that certain ellipsoids with three unequal axes were possible figures, while

Thomson and Tait pointed out that figures consisting of one, two, or more rings may be figures of equilibrium, although probably few of these will be stable.

The subject, of course, derives its great interest from its bearing on the origin of stellar systems and on Laplace's nebular hypothesis in particular; consequently the question of stability or instability is one of extreme importance. As an actual nebula in space loses its heat it will shrink in size, while keeping its angular momentum constant. For abstract discussion it is easier to deal with a fictitious mass of fluid of constant size, the angular momentum of which continually increases. Unless some cataclysmic breakdown occurs, this rotating mass must find for itself a continuous path through series of configurations of equilibrium all of which are stable. The problem of fundamental importance for cosmogony is that of discovering the far end of this path. Do we see it represented, as Kant and Laplace may have thought, in Saturn and his rings, or do we see it, as Sir George Darwin and others now think probable, in the earth-moon type of system? Or does the path lead only for a certain way through stable continuous configurations, and then end in a cataclysm?

This is the problem on which Sir George Darwin has for some years been leading the attack. Obviously there are the two methods of trying to trace out the path from the beginning to the end, and of trying to guess at the end and construct the path back to the beginning. Papers ix. and xv. of the present volume are devoted to the latter method. If increased rotation is going to lead to an earth-moon system, it ought to be possible to trace back the earth-moon system through diminishing rotation and through continuous stable configurations to the initial spherical form. In this connection, Sir George Darwin has directed attention to some almost overlooked, although highly important, work of Roche, who showed that a system consisting of a planet with an infinitesimal satellite in contact cannot be stable. He has accordingly attempted to examine above what limit the ratio of the masses of satellite to primary must lie for stability to be ensured. No perfectly definite conclusion is reached, but it seems as if the limit must be greater than the ratios observed in the solar system. This somewhat nugatory result is disappointing, and suggests that a better way of attacking the problem may be the direct one of examining all possible series of configurations, starting from the initial sphere.

The only road which the fluid can take on leaving the spherical form consists of the series of Maclaurin's spheroids, but this road is intersected by an infinite number of cross-roads at different points ("points of bifurcation"). At the first point of bifurcation, the series of Maclaurin's spheroids loses its stability, and the configurations represented on the cross-road through this point are found to be stable. Moreover, it appears that this particular cross-road represents the well-known series of Jacobian ellipsoids. Poincaré has shown that this road also is intersected by an infinite number of cross-roads, and that the first of these cross-roads represents a series of pear-shaped figures which look as though they might end by

dividing into a large and a small mass. At this stage everything turns on the question of which is stable of the series of figures through this point of bifurcation, the Jacobian ellipsoids on the main road, or the pear-shaped figures on the cross-road. Sir George Darwin believes he has proved the pear-shaped figures to be stable, but M. Liapounoff challenges this, and, as the result of an independent investigation, thinks these figures are unstable. Each investigator has again verified his own calculations, and Sir George Darwin has applied various checks to his work which afford some evidence, although not proof, that his original conclusion was accurate.

Here the problem at present stands, at a deadlock. Short of discovering a serious error in one or other of the two investigations, the only explanation of the discrepancy seems to lie in the rejection of certain remote, and apparently very small, terms by Darwin. These might possibly be found to turn the balance, but it is almost inconceivable that they should.

Whatever the outcome may be, the present volume stands as a record of the amount of patient labour and degree of mathematical and scientific skill brought by one worker to the examination of one theory of cosmogony. Before the scientific world permits other theories to take their place by the side of this one, it will do well to ask whether the truth of these other theories has been investigated with a degree of patience, skill, and power at all comparable with what is shown here.

THE POLAR WORLD AND GLACIAL GEOLOGY.

Die Polarwelt und ihre Nachbarländer. By O. Nordenskjöld. Pp. vii+220; 77 figures. (Leipzig: B. G. Teubner, 1909.) Price 8 marks.

DR. OTTO NORDENSKJÖLD is especially well qualified for a comparison of the Arctic and Antarctic regions, which he has personally explored in Greenland, Iceland, Spitsbergen, Alaska, Patagonia, and during his leadership of the Swedish Antarctic Expedition. He has now issued a short work on the polar world, in which he has given a general geographical description of the Arctic and Antarctic lands, and reference to the interesting problems connected with their geographical structure, inhabitants, and glacial geology. The book is based on a series of popular lectures and is issued without references. It is illustrated by seventy-six views, mostly taken by the author or on expeditions of which he was a member. The only map is a sketch of part of southern Patagonia.

The book owes its main value to its statement of the author's conclusions relating to various geographical and geological problems in which he is especially interested. Greenland is naturally described first, as it is the typical polar country, it being the most accessible and best-known land still covered with an ice-sheet. The author rejects Nansen's view of the nature of its ice gradient, and says that the problem of the Greenland inland ice was not solved by his expedition, which crossed the country at its narrow

southern end, where the glacial conditions are not fully representative.

Dr. Nordenskjöld describes the fiord system of north-eastern Greenland, which he considers as the greatest in the world. Its valleys were once occupied by glaciers during a former greater extension of the Greenland ice cap; unless they had been filled with ice he would refuse them the name of fiords. He admits that part of Greenland has never been covered by ice, though he remarks that the evidence for this conclusion must be treated with caution. He briefly discusses the Eskimo, the most interesting of polar people. He accepts their Asiatic origin as apparently beyond question; the problem regarding them which he regards as still unsolved is the home of their present culture. Hamberg has suggested that the race developed its special characters in Alaska, but Dr. Nordenskjöld doubts this conclusion, as he thinks it probable that, if so, they would have spread westward into Asia, where but few of them occur, as well as eastward. He thinks their last home was probably within the centre of their present area of distribution, and not on its margin.

After describing Iceland and Jan Mayen, Dr. Nordenskjöld turns with enthusiasm to Spitsbergen, which he describes as the classical land of Arctic research. It is at present of little economic value, as it has been abandoned alike by whale, walrus, and seal hunters. Since 1905 attempts have been made to mine its coal, but Dr. Nordenskjöld regards the success of these attempts as very doubtful; and he thinks the country will be mainly of value as a tourist resort. He raises the question of the ownership of Spitsbergen, refers to the respective titles to its possession by Holland, Great Britain, Norway, Sweden, and Russia. A conference between the last States is now discussing the political status of the archipelago.

Dr. Nordenskjöld also describes the Arctic areas of America and Siberia, and gives a brief summary of recent work on the Antarctic, with an account of southern Patagonia, and a reference to Tasmania and New Zealand. He directs attention to the evidence of the former greater extension of ice in nearly all polar and subpolar countries, and he recurs frequently throughout the lectures to glacial problems. As the cause of the former glacier extension he regards Arrhenius's theory of refrigeration of the earth owing to the diminution in the carbonic dioxide in the atmosphere as inherently probable; he admits, however, that the chief different glacial centres of North America and elsewhere are not contemporaneous, that there was no equivalent glaciation of Siberia, and that there is no evidence of a former existence of ice in some parts of Alaska as in the Yukon district. The oft-made suggestion that the ice developed in localities which had a moist climate and heavy snowfall he rejects from the evidence of Kerguelen, where, in spite of these conditions, there is much ice-free land. Kerguelen, however, is only in the latitude of Paris.

Consideration of the westward extension of the Scandinavian ice-sheet leads him to consider the general belief that the Scandinavian ice filled the North Sea and deflected the local glaciers northward.